Using ShoreZone Inventory Data to Identify Potential Forage Fish Spawning Habitat

Blain Reeves, Betty Bookheim *and* ***Helen Berry***
Washington State Department of Natural Resources

John Harper *and* ***Neil Borecky***
Coastal and Ocean Resources, Inc.

Abstract
The Washington State ShoreZone Inventory provides a consistent, landscape-scale description of marine shoreline components and habitats. In total, the project inventoried 3067 miles of Washington's marine shoreline. The resulting GIS data set includes 50 parameters that describe important physical, anthropogenic, and biological features of the shore zone.

The Inventory data has been used as a planning tool for a multitude of nearshore projects. A recent comparison using ShoreZone beach types and Washington Department of Fish and Wildlife beach spawning data prove ShoreZone data are an effective screening tool for identifying potential forage fish spawning beaches. On the ground survey results show an 88% correlation between actual spawning locale and four ShoreZone beach types. These analyses can generate a map of potential areas of forage fish spawning beaches or focus field investigations thus reducing overall field effort. Further analysis of component data are on-going and will explore more detailed spatial patterns related to distribution of spawning beaches and other shoreline features. The ShoreZone Inventory data set has a wide range of applications for habitat planning, management, and conserving sensitive resources. Many local efforts continue to utilize this information to support more informed decision-making about the uses of the coastal zone.

Background
Forage fish are recognized to be important prey items for fish, birds, mammals, and wildlife in our region. Due to the important role of the food web of forage fish, and the prevalence of human development in upper intertidal areas where forage fish spawn, there is increasing interest in identifying forage fish spawning beaches for research and management. Many groups currently survey beaches for forage fish spawning, including the Washington State Department of Fish and Wildlife (WDFW), Marine Resource Committees (MRCs), and other nearshore habitat assessment projects. These efforts are challenged to survey thousands of miles of shoreline with limited funds.

This project tested our ability to identify areas of high probability for forage fish spawning using existing data sets. If the data sets showed high correlation, the results could be used as a screening tool to: (1) prioritize forage fish spawning field surveys where funding exists; and (2) model potential spawning habitats where field surveys are not currently feasible.

We compared two datasets for the coastal region of Washington State to identify potential sand lance and surf smelt spawning habitat, the Washington State Department of Natural Resources (WADNR) ShoreZone Inventory and the WDFW Beach Spawner data set.

The WADNR ShoreZone Inventory provides a consistent, landscape-scale description of nearshore habitats (Berry 2001). The helicopter-based inventory divides the shoreline into alongshore *units* that have uniform morphology and exposure, and represents these units as line segments on maps. Attributes of each *unit*, such as general morphology, substrate, wave exposure, stability, and biological characteristics are recorded in the Unit Database. Each *unit* is further subdivided into across-shore *components*, which describe physical and biological features between the supra-tidal and the shallow subtidal, including form, material, slope, width and biological characteristics. These attributes are recorded in a Component Database.

The WDFW spawn data set has been developed from more than 30 years of sample data throughout Washington (Pentilla 2001). It is generally similar in resolution to the ShoreZone Inventory. The WDFW data set was created by extrapolating all positive surf smelt and sand lance spawn samples obtained in beach surveys to form an arc extending 500 feet along shore in either direction (1,000 foot total) at the same beach height. These line data were compiled into an ArcInfo map format to show the distribution of spawn habitat. There are limitations to the data. Despite years of fieldwork, many beaches have not yet been surveyed. Additionally, the dataset does not differentiate between absence and no data

The two datasets were initially compared in ArcView to examine spatial overlap between the two. The arcs from the spawning data did not always completely overlap with the arcs from the ShoreZone Inventory. Therefore, we calculated the amount of spawning arc (to nearest 10% that occurs within each ShoreZone unit and coded the ShoreZone database accordingly. We then tested for the optimal level of overlap between the two data sets and determined that 80% produced the best correlations, used the most available spawn data to correlate with ShoreZone attributes, and introduced the least amount of statistical noise. We then ran the following two modeling scenarios based on the 80% arc overlap criteria:

- The low-resolution model correlated sand lance and surf smelt spawning occurrence to shore types statewide

- The high-resolution model correlated sand lance occurrence to beach form and materials in the upper intertidal zone within the Puget Sound basin

Findings

The low-resolution model showed a tight correlation between forage fish spawning occurrences and basic habitat characteristics. The vast majority of sand lance spawn occurrence (>90%) is associated with five (34 total) shore types statewide. The shore types that sand lance spawn sites occurred on the majority of the time are sand flat (26.3%), sand and gravel flat (24%), narrow sand beach (18%), narrow sand and gravel beach (16.8%), and sand beach (7.0%). Next, greater than 90% of surf smelt spawn occurrence is associated with just four shore types. The shore types that surf smelt spawn sites occurred on the most are narrow sand and gravel beach (30%), narrow sand beach (25.8%), sand flat (17.5%) and sand and gravel flat (17%).

The low-resolution model also correlated spawn occurrence to wave exposure in ShoreZone units with greater than 80% arc overlap between the datasets. These data indicate a strong co-occurrence of sand lance spawn sites with protected or semi-protected exposure levels (>90%) and very little association with semi-exposed (<5%) or very protected (<2%) beaches. Surf smelt spawn sites had an even higher correlation to protected or semi-protected beaches (>95%) and little association with very protected beaches (<2%) or semi-exposed beaches (0%). There are no documented surf smelt spawning beaches on the outer coast and within the Straits of Juan de Fuca in the WDFW spawn data set.

The high-resolution model showed interesting correlations between spawn occurrence and upper intertidal beach forms. Greater than 90% of sand lance spawn occurrence is associated with four beach forms. Those upper intertidal beach forms where sand lance spawn sites occurred the majority of the time are beach face (65.1%), beach berm (15%), seawall (11.1%) and beach incline (5.4%). More than 90% of surf smelt spawn occurrence is associated with just two beach forms in the upper intertidal zone. Those two beach forms are beach face (81%) and seawall (11%). The high correlation between spawn occurrence and seawalls is interesting but not surprising considering nearly 10% of the shorelines in Puget Sound have a seawall identified in the upper intertidal zone in the ShoreZone Inventory.

The high-resolution model also correlated spawn occurrence to materials in the upper intertidal zone. Almost 55% of the sand lance spawn occurrence is associated with four upper intertidal beach materials. The upper intertidal beach materials most highly correlated to sand lance spawn occurrence are sand over pebble (23.4%), sand (15.6%), pebble veneer over sand (7.9%) and pebble over sand (7.1%). More than 60% of the surf smelt spawn occurrence is associated with four upper intertidal beach materials. The upper intertidal beach materials most highly correlated to surf smelt spawn occurrence are pebble veneer over sand (24%), sand over pebble (20%), sand (10%) and pebble over sand (8%).

Key Points

After analyzing and discussing these results with a WDFW forage fish expert, we conclude the following are significant characteristics of sand lance and surf smelt spawning habitat:

Sand lance—The preferred spawning substrate is sand on low exposure beaches, although they will spawn where there is a mixture of sand and pebble. The spawn location is in the upper intertidal zone, below the mean-higher high water level but above the mid-tide level. There appears to be preference for “soft” sand beaches and many of the sites appeared to be associated with drift logs in the upper intertidal zone.

Surf Smelt—The preferred spawning substrate is sand on low exposure beaches; the surf smelt appear to be slightly less selective about substrate than are sand lance. The surf smelt do not spawn quite as close to the mean high water line as do the sand lance but spawn appears to be generally above the mid tide level. Surf smelt do not appear to be as selective about harder or softer sand substrate as the sand lance. Spawning sites are commonly associated with intertidal drift logs.

Conclusions

Existing information on habitats and spawning occurrences can be used to identify areas of high probability for forage fish spawning. The correlation between the two datasets allowed us to select a comparatively small subset of potential spawning beaches from the shoreline as a whole. These results are potentially useful as a screening tool to identify high priority areas for field surveys. In areas where field surveys are not feasible, the results can be used to model potential spawning areas. These results are potentially applicable beyond Washington State. For example, ShoreZone mapping has been completed throughout British Columbia and in portions of Alaska, yet few field surveys have been completed to date mapping forage fish spawning.

References

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